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Adherence to the Mediterranean diet and body fat distribution in reproductive aged women

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Abstract

Background/Objectives—Adherence to the Mediterranean Diet (MD) high in fruits, vegetables and monounsaturated fats, has been associated with lower body mass index. Associations with measured body fat, including regional adiposity, have not been previously investigated. We examined the associations between the alternate Mediterranean Diet Score (aMED), anthropometry and measured adiposity by dual energy x-ray absorptiometry.

Subjects/Methods—This study included 248 healthy females, aged 18–44 years from the BioCycle Study. Each woman's aMED (range 0–9) was calculated from up to eight 24-hr dietary recalls over 1–2 menstrual cycles (>97% had ≥7 recalls). Multiple linear regression was used to determine whether aMED and its specific components were associated with total and regional adiposity after adjusting for age, race, education, physical activity and energy intake.

Results—Participants had an average (SD) aMED of 4.2 (1.7) and percent body fat of 29.5 (6.0)%. Significant inverse associations were found between aMED and all the examined adiposity measures except waist to hip ratio. Among the DXA measures, a 1-unit increment in aMED was associated with a 0.06 (95% CI:−0.09,−0.02) lower trunk-to-leg fat ratio (T/L), a measure of upper to lower body fat. In an analysis examining T/L as an outcome with the separate components of the aMED, T/L was lower with increased legume consumption (β=−0.280, 95% CI:−0.550,−0.010) but was higher with increased consumption of red and processed meat (β=0.060, 95% CI:0.002,0.117).

Conclusions—Adherence to the aMED was associated with lower total and regional adiposity, adding to the mounting evidence of the health benefits of the MD.

Keywords

Mediterranean Diet; body fat; trunk fat; regional adiposity; obesity; body mass index; DXA

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

INTRODUCTION

A dramatic increase in obesity in the United States has occurred over the past twenty years.[1] In 2009–2010, 32% (95% CI: 29%–36%) of reproductive aged US women (20–39 y) were obese (body mass index [BMI]≥30kg/m^2).[2] Obesity among women of reproductive age carries its toll with the increased risks of infertility, pregnancy complications as well as adverse offspring outcomes.[3;4]

Dietary intake plays a pivotal role in the rising obesity rates. In particular, examination of dietary patterns, rather than individual nutrients or foods, can capture interactions between separate dietary components.[5] One dietary pattern that has been explored in studying obesity is the Mediterranean diet (MD). The traditional MD reflects food patterns found in Greece and Southern Italy in the early 1960s, and is characterized by an abundant intake of plant foods (vegetables, legumes, fruits, nuts, cereals) with olive oil as the main source of fat, a high to moderate intake of fish, a low to moderate consumption of eggs, dairy products (mainly cheese and yogurt) and poultry, a low intake of red meat, and a regular but moderate intake of alcohol (mainly wine during meals).[6;7]

Previous studies examining the association between the MD and obesity have mainly assessed BMI and/or waist circumference, as surrogate measures of total and regional adiposity.[8] Associations between the MD pattern and measured body fat, including regional adiposity however, have not been previously investigated among women of reproductive age. Regional adiposity, independent of overall obesity, is a well-recognized risk factor for cardiovascular disease, type 2 diabetes, gestational diabetes and mortality.[9;10] We thus examined the association between the MD, total and regional adiposity by dual-energy X-ray absorptiometry (DXA) and replicated previous findings of the associations between the MD and anthropometry measures using data from healthy premenopausal women participating in the BioCycle Study.

MATERIALS AND METHODS

Study Participants

The BioCycle Study was originally designed to study the association between endogenous sex hormones and oxidative stress.[11] Between 2005 and 2006, 259 healthy premenopausal women 18–44 years of age from western New York were followed for 1 (n=9) or 2 (n=250) menstrual cycles and attended up to eight clinic visits per cycle (93.4% with 7–8 visits in cycle 1, 95.6% with 7–8 visits in cycle 2). The visits corresponded to specific menstrual cycle time points with the most hormonal variation, approximately days 2, 7, 12, 13, 14, 18, 22 and 27 of a 28-day cycle adjusted for cycle duration. Cycle visits were routinely scheduled in the morning and the study clinic was open 7 days per week. Main sources of recruitment included study flyers and friends or family referrals who knew about the study or were current study participants.

Participants were not eligible to participate if they were currently using oral contraceptives, vitamin and mineral supplements, or prescription medications; were pregnant or breastfeeding in the past 6 months; had a diagnosis of a chronic medical condition such as metabolic disorders or gastrointestinal diseases; reported a BMI of <18 or >35 kg/m^2 at screening; or were on current dietary restrictions for weight loss or for medical reasons. Detailed study methods have been published elsewhere.[11] Only participants who had body composition measurements by DXA during their final study visit are included in the current analyses (n=248; 96%). The University at Buffalo Health Sciences Institutional Review Board (IRB) approved the study and served as the IRB designated by the National Institutes of Health for this study under a reliance agreement. All participants provided written informed consent.

Adiposity Measures

Anthropometry—Trained study personnel performed anthropometric measures at the baseline visit according to standardized protocols. Height was measured by a fixed Stadiometer while weight was measured on a calibrated balance scale. BMI was calculated by dividing weight in kilograms by height in meters squared (kg/m^2). Waist, hip, and thigh circumferences were measured in centimeters to the nearest mm with an inelastic measuring tape. Waist circumference was measured at the end of normal expiration midpoint between the iliac crest and the lowest lateral portion of the rib cage. Hip girth was measured at the level of the symphysis pubis and the maximal protrusion of the gluteal muscles. Thigh circumference was measured at the midpoint between the inguinal crease and the proximal border of the patella. Skinfold thicknesses were measured at the triceps (mid-point between the acromion process of the scapula and the inferior margin of the olecranon process of the ulna), thighs (mid-point between the inguinal crease and the proximal border of the patella), subscapular (below the angle of the scapula) and suprailiac (midaxillary line above the iliac crest) to the nearest 1 mm using a Harpenden skinfold caliper. All the anthropometric measurements were done twice and the mean values were obtained from the two measurements.

Body Composition—Certified radiology technicians performed body composition assessments at the final clinic visit (n=248) using dual energy X-ray absorptiometry (Hologic Discovery Elite, Hologic, Waltham, MA, USA). Ongoing QC and daily phantoms were used to monitor any machine drift. Whole body assessment (distribution of bone, fat and lean mass) was performed. Total and regional (arms, trunk, and legs) bone mass, percent fat and regional fat mass were assessed. Trunk and leg fat were used to compute trunk-to-leg fat ratio (T/L), as a measure of upper to lower body fat. Percent leg fat was calculated as the average amount of fat in both legs divided by total body fat × 100.

Dietary Assessment

24-hour Recall—24-hr dietary recalls were administered on approximately days 2, 7, 14 and 22 of the menstrual cycle. As such, women could have up to eight 24-hr recalls if they completed 2 cycles. The 24-hr recalls were conducted by trained and certified staff through a computerized interview at the time of the morning clinic visit or after 8 pm the prior evening (after fasting has begun) and were administered either by telephone or in person. The Nutrition Data System for Research software (NDSR), version 2005 (Nutrition Coordinating Center of the University of Minnesota, Minneapolis, MN) was used to derive nutritional information. A validated two-dimensional visual aid helped participants estimate accurate information regarding portion sizes.[12] 97.2% of the participants with DXA measures completed more than six 24-hr dietary recalls during the two cycles (7 recalls: 21.4%; 8 recalls: 75.8%). Energy intake was averaged across all available recalls per participant.

Alternate Mediterranean Diet Score (aMED)—The alternate Mediterranean Diet Score (aMED),[13] a scale adapted from the traditional Mediterranean diet score developed by Trichopoulou et al.,[14] is based on the dietary intake of 9 components including: vegetables (excluding potatoes), legumes, fruit, nuts, whole grains, red and processed meat, fish, alcohol, and the ratio of monounsaturated fat to saturated fat. The aMED ranges between 0 and 9 with higher scores implying greater adherence. Each dietary component receives a score of 1 if consumption exceeds the median intake except for: the red and processed meat component (a point is scored if consumption is less than the median intake) and the alcohol component (a point is scored if intake is between 5 and 15 grams per day). The median intake is derived from the distribution of the dietary intake components of the cohort under study.[14]

As each participant had more than one dietary recall (4–8 recalls), we calculated the average of each of the aMED dietary components across all available recalls per participant and subsequently calculated one aMED per subject.

Covariate Assessment

Participants reported demographic information including education, race and smoking by questionnaire. The International Physical Activity Questionnaire (IPAQ) was administered at baseline and was used to classify physical activity into high, moderate or low.[15]

Statistical Analyses

Descriptive analyses are presented as means ± standard deviations for normally distributed continuous variables, and as absolute numbers and frequencies for categorical variables by aMED category. Chi-square test or Fisher's exact test were used to examine the associations between categorical variables. Differences of mean aMED components and of mean adiposity measurements across the aMED categories (0–3, 4–5, 6–9) were evaluated with analysis of variance (ANOVA). ANOVA was also used to examine pairwise contrasts in mean adiposity measurements across the aMED categories. We then used multiple linear regression models to test the associations between the aMED and the different adiposity outcomes (percent body fat, percent trunk fat, percent leg fat, T/L, sum of skinfolds, waist circumference, hip circumference, waist-to-hip ratio [WHR], BMI) adjusting first for average energy intake across the dietary recalls (kcal) and in subsequent models additionally adjusting for age (continuous), physical activity (high, moderate, low), education (high school or less/GED, some college, associates or bachelor degree, graduate degree or higher) and race (white, black, other). The choice of covariates was based *a priori* on what was previously reported in the literature. Due to the increased risk of morbidities associated with regional obesity, we further examined the average intake of the individual aMED components by tertiles of T/L and evaluated the associations between each aMED component (independent) and T/L (dependent, continuous) using separate multiple linear regression models adjusting for average energy intake, age, physical activity, education and race. The homogeneity of variance and the independence of the errors assumptions for performing these tests were met. Additionally, our results are robust to the normality of errors assumption due to our large sample size.[16] Results from the linear regression models are presented as β-coefficients and 95% confidence intervals (CI). All reported p-values are based on a two-sided test with a p-value <0.05 considered statistically significant. SAS version 9.2 (SAS Institute Inc., Cary, NC, USA) was used for all analyses.

RESULTS

Overall, the mean age of this cohort was 27.5 years, 35% had a low aMED (score 0–3) while 22% had a high score (score 6–9). A larger proportion of white women reported a high aMED than women of other race (p=0.07) (Table 1). More than 50% of the participants reported high levels of physical activity with a larger proportion of these women reporting a low aMED (p=0.04). Energy intake increased with increasing aMED. Of the macronutrients, a higher aMED was associated with slightly greater carbohydrate intake but no difference in protein intake. The type of fat consumed significantly differed, with lower saturated and higher polyunsaturated fat among those with a high aMED. As expected, the individual aMED components were directly associated with the aMED in the hypothesized directions.

Women with moderate and high aMED had a significantly lower BMI, smaller waist and thigh circumferences measured at baseline than women with low aMED (Table 2). All of the examined DXA measures except for percent leg fat showed an inverse association with the aMED ($p<0.05$). Hip circumference and leg fat mass were only significantly different when comparing the moderate aMED to the low aMED group (Table 2). Associations remained significant after adjusting for age, race, education, physical activity, and total energy intake (Table 3). An increment of 1-unit in the aMED was associated with a 0.67% (95% CI: −1.11,−0.24) lower percent body fat, a 0.85% (95% CI: −1.39,−0.32) lower percent trunk fat, and a 0.06% (95% CI: −0.09,−0.02) lower T/L ratio.

Intake of red and processed meat increased with the increase in tertiles of T/L (mean intake (SD)=1.3 servings/d (1.1) in the lowest tertile, 1.5 servings/d (1.2) in the moderate tertile, 1.8 servings/d (1.2) in the highest tertile of T/L). Significant differences were also noted for %SFA with the highest tertile of T/L having the highest %SFA intake (Table 4). When the associations between the individual dietary components of the aMED and regional adiposity as a measure of T/L were evaluated in linear regression models adjusting for age, race, education, physical activity and total energy intake, a high consumption of red and processed meat products and low intake of legumes were significantly associated with increased regional adiposity ($p=0.04$) (red and processed meat $\beta=0.060$, 95% CI:0.002, 0.117; legumes $\beta=-0.280$, 95% CI:−0.550, −0.010) (Table 5). Mutually adjusting for the other aMED dietary components reduced the associations with T/L (red and processed meat $\beta=0.052$, 95% CI: −0.011, 0.114; legumes $\beta=-0.25$, 95% CI: −0.57,0.08; $p=0.1$ data not shown).

As energy intake was significantly related to the aMED and given that the MD might be inherently positively associated with energy intake,[17–19] we also conducted analyses without controlling for energy intake. No qualitative changes were noted in the results (data not shown).

DISCUSSION

In this cross-sectional analysis, following the principles of a Mediterranean dietary pattern was significantly associated with lower values of total and regional adiposity by DXA and by anthropometry. This association held even after adjusting for potential confounders including age, education, race, physical activity, and energy intake.

To our knowledge our findings represent the first demonstration examining the relationship between adherence to the alternate Mediterranean diet and a direct assessment of total and regional body fat distribution as measured by DXA. These findings are in agreement with previous studies, despite methodological differences (types of study designs, adiposity measurement methods, study populations), showing that following the aMED could potentially be associated with a favorable body weight. Nine cross-sectional studies, of which 6 examined BMI and 3 examined both BMI and WHR/waist circumference, have shown inverse associations with the above adiposity outcomes among study participants with better adherence to the MD.[13;18–25]. Similarly, 3 of 5 cohort studies, with follow-up ranging between 2.4–9 years, showed that subjects with better adherence to the MD were less likely to gain weight or to develop overweight/obesity than were individuals with low adherence while the other two cohort studies did not demonstrate any significant weight change.[26–30]

The potential physiologic mechanisms explaining the protective role of the MD on obesity, the metabolic syndrome and its components as well as cardiovascular disease have been reviewed elsewhere. Briefly, the overall anti-inflammatory and anti-oxidant impact of the

MD and the effects of its individual components including olive oil, fruits, vegetables, whole grains, and fish offer potential explanations for its protective effects.[31–33] Particularly essential in the prevention of weight gain is the high consumption of dietary fiber with its satiation impact, coupled with a low degree of energy density of the MD overall.[33] In a meta-analysis of over 500,000 subjects, a decrease of 0.42 cm (95% CI: −0.82,−0.02) in waist circumference has been reported among subjects with high adherence to the MD.[33;34] This is particularly important for the population under study. Women of reproductive age due to the childbearing process, are at high risk for obesity development and excessive weight gain during pregnancy with preferential centralized distribution of adipose tissue, a risk factor for a wide range of chronic diseases.[35–37] Our study results support a strong inverse association between measured truncal adiposity and adherence to the aMED implying that not following such a pattern of dietary consumption may be potentially associated with a preference in fat distribution. In a randomized crossover study of overweight or obese men (aged 24–49 years, BMI 25.5–31.3 kg/m^2), a significant loss of weight and fat mass resulted after 4 weeks when SFA-rich diet was substituted with predominantly MUFA-rich diet. Men on the SFA-rich diet accumulated fat mass predominantly on the trunk instead of the limbs.[38] The aMED heavily reflects on the fatty acid component of this diet through mainly 4 categories including meat, nuts, fish and MUFA to SFA ratio. Interestingly, a food group analysis with T/L shows a difference in consumption for red and processed meat and consumption of legumes. High red and processed meat consumption have been previously associated with increased cardiometabolic risk independent of other dietary factors.[39;40] The lack of an appreciable association with the majority of the individual dietary components of the aMED, might be attributed to the inability of the individual components to capture the synergistic or interactive cumulative effects on adiposity detected through the diet score.[14]

The findings of this study should be interpreted in light of the study's strengths and limitations. As this study had a cross sectional design, we are restricted in terms of making an inference on the time sequence of all associations. The BioCycle study however, excluded women on a diet for weight loss or for other medical reasons rendering the likelihood of reverse causality less likely to occur. We also had strict inclusion criteria restricting the generalizability of our findings to all US women. While we used non-objective measurements in assessing physical activity, the instrument we used has previously demonstrated acceptable reliability and validity.[15] Strengths of the current study include the use of the 24 h dietary recalls with repeated nutritional assessments (>97% had ≥7 recalls) over a period of 2 months rendering misreporting of consumed food items unlikely.

In conclusion, we confirmed previous findings that showed an inverse relation between the aMED and anthropometric indices, including waist circumference, WHR and BMI, and expanded those findings to show the association with total and regional body fat distribution as measured by DXA. These results in addition to the mounting evidence of the health benefits of the Mediterranean diet raise awareness to promote such a lifestyle in dietary habits to combat the worldwide obesity epidemic.

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Abbreviations

aMED	Alternate Mediterranean Diet Score
BMI	Body Mass Index
DXA	Dual Energy X-ray Absorptiometry
MD	Mediterranean Diet
MUFA	Monounsaturated Fatty Acid
PUFA	Polyunsaturated Fatty Acid
SFA	Saturated Fatty Acid
T/L	Trunk-to-Leg Fat Ratio
WHR	Waist-to-Hip Ratio

References

1. Centers for Disease Control and Prevention. Overweight and obesity. http://www.cdc.gov/obesity/data/adult.html [cited 2012 Jun 18]
2. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. JAMA. 2012; 307:491–497. [PubMed: 22253363]
3. Pasquali R, Patton L, Gambineri A. Obesity and infertility. Curr Opin Endocrinol Diabetes Obes. 2007; 14:482–487. [PubMed: 17982356]
4. Zera C, McGirr S, Oken E. Screening for obesity in reproductive-aged women. Prev Chronic Dis. 2011; 8:A125. [PubMed: 22005618]
5. Jacques PF, Tucker KL. Are dietary patterns useful for understanding the role of diet in chronic disease? Am J Clin Nutr. 2001; 73:1–2. [PubMed: 11124739]
6. Bach-Faig A, Berry EM, Lairon D, Reguant J, Trichopoulou A, Dernini S, et al. Mediterranean diet pyramid today. Science and cultural updates. Public Health Nutr. 2011; 14:2274–2284. [PubMed: 22166184]
7. Willett WC, Sacks F, Trichopoulou A, Drescher G, Ferro-Luzzi A, Helsing E, et al. Mediterranean diet pyramid: a cultural model for healthy eating. Am J Clin Nutr. 1995; 61:1402S–1406S. [PubMed: 7754995]
8. Buckland G, Bach A, Serra-Majem L. Obesity and the Mediterranean diet: a systematic review of observational and intervention studies. Obes Rev. 2008; 9:582–593. [PubMed: 18547378]
9. Branchtein L, Schmidt MI, Mengue SS, Reichelt AJ, Matos MC, Duncan BB. Waist circumference and waist-to-hip ratio are related to gestational glucose tolerance. Diabetes Care. 1997; 20:509–511. [PubMed: 9096970]
10. Snijder MB, van Dam RM, Visser M, Seidell JC. What aspects of body fat are particularly hazardous and how do we measure them? Int J Epidemiol. 2006; 35:83–92. [PubMed: 16339600]
11. Wactawski-Wende J, Schisterman EF, Hovey KM, Howards PP, Browne RW, Hediger M, et al. BioCycle study: design of the longitudinal study of the oxidative stress and hormone variation during the menstrual cycle. Paediatr Perinat Epidemiol. 2009; 23:171–184. [PubMed: 19159403]
12. Posner BM, Smigelski C, Duggal A, Morgan JL, Cobb J, Cupples LA. Validation of two-dimensional models for estimation of portion size in nutrition research. J Am Diet Assoc. 1992; 92:738–741. [PubMed: 1607574]
13. Fung TT, McCullough ML, Newby PK, Manson JE, Meigs JB, Rifai N, et al. Diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction. Am J Clin Nutr. 2005; 82:163–173. [PubMed: 16002815]
14. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. N Engl J Med. 2003; 348:2599–2608. [PubMed: 12826634]

15. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003; 35:1381–1395. [PubMed: 12900694]
16. Lumley T, Diehr P, Emerson S, Chen L. The importance of the normality assumption in large public health data sets. Annu Rev Public Health. 2002; 23:151–169. [PubMed: 11910059]
17. Martinez-Gonzalez MA, de lF-A, Nunez-Cordoba JM, Basterra-Gortari FJ, Beunza JJ, Vazquez Z, et al. Adherence to Mediterranean diet and risk of developing diabetes: prospective cohort study. BMJ. 2008; 336:1348–1351. [PubMed: 18511765]
18. Romaguera D, Norat T, Mouw T, May AM, Bamia C, Slimani N, et al. Adherence to the Mediterranean diet is associated with lower abdominal adiposity in European men and women. J Nutr. 2009; 139:1728–1737. [PubMed: 19571036]
19. Trichopoulou A, Naska A, Orfanos P, Trichopoulos D. Mediterranean diet in relation to body mass index and waist-to-hip ratio: the Greek European Prospective Investigation into Cancer and Nutrition Study. Am J Clin Nutr. 2005; 82:935–940. [PubMed: 16280422]
20. Panagiotakos DB, Chrysohoou C, Pitsavos C, Stefanadis C. Association between the prevalence of obesity and adherence to the Mediterranean diet: the ATTICA study. Nutrition. 2006; 22:449–456. [PubMed: 16457990]
21. Panagiotakos DB, Polystipioti A, Papairakleous N, Polychronopoulos E. Long-term adoption of a Mediterranean diet is associated with a better health status in elderly people; a cross-sectional survey in Cyprus. Asia Pac J Clin Nutr. 2007; 16:331–337. [PubMed: 17468091]
22. Rossi M, Negri E, Bosetti C, Dal ML, Talamini R, Giacosa A, et al. Mediterranean diet in relation to body mass index and waist-to-hip ratio. Public Health Nutr. 2008; 11:214–217. [PubMed: 17686205]
23. Schroder H, Marrugat J, Vila J, Covas MI, Elosua R. Adherence to the traditional mediterranean diet is inversely associated with body mass index and obesity in a spanish population. J Nutr. 2004; 134:3355–3361. [PubMed: 15570037]
24. Schroder H, Mendez MA, Ribas-Barba L, Covas MI, Serra-Majem L. Mediterranean diet and waist circumference in a representative national sample of young Spaniards. Int J Pediatr Obes. 2010; 5:516–519. [PubMed: 20863166]
25. Shubair MM, McColl RS, Hanning RM. Mediterranean dietary components and body mass index in adults: the peel nutrition and heart health survey. Chronic Dis Can. 2005; 26:43–51. [PubMed: 16251009]
26. Beunza JJ, Toledo E, Hu FB, Bes-Rastrollo M, Serrano-Martinez M, Sanchez-Villegas A, et al. Adherence to the Mediterranean diet, long-term weight change, and incident overweight or obesity: the Seguimiento Universidad de Navarra (SUN) cohort. Am J Clin Nutr. 2010; 92:1484–1493. [PubMed: 20962161]
27. Mendez MA, Popkin BM, Jakszyn P, Berenguer A, Tormo MJ, Sanchez MJ, et al. Adherence to a Mediterranean diet is associated with reduced 3-year incidence of obesity. J Nutr. 2006; 136:2934–2938. [PubMed: 17056825]
28. Romaguera D, Norat T, Vergnaud AC, Mouw T, May AM, Agudo A, et al. Mediterranean dietary patterns and prospective weight change in participants of the EPIC-PANACEA project. Am J Clin Nutr. 2010; 92:912–921. [PubMed: 20810975]
29. Sanchez-Villegas A, Bes-Rastrollo M, Martinez-Gonzalez MA, Serra-Majem L. Adherence to a Mediterranean dietary pattern and weight gain in a follow-up study: the SUN cohort. Int J Obes (Lond). 2006; 30:350–358. [PubMed: 16231028]
30. Woo J, Cheung B, Ho S, Sham A, Lam TH. Influence of dietary pattern on the development of overweight in a Chinese population. Eur J Clin Nutr. 2008; 62:480–487. [PubMed: 17327865]
31. Dai J, Jones DP, Goldberg J, Ziegler TR, Bostick RM, Wilson PW, et al. Association between adherence to the Mediterranean diet and oxidative stress. Am J Clin Nutr. 2008; 88:1364–1370. [PubMed: 18996873]
32. Gaskins AJ, Rovner AJ, Mumford SL, Yeung E, Browne RW, Trevisan M, et al. Adherence to a Mediterranean diet and plasma concentrations of lipid peroxidation in premenopausal women. Am J Clin Nutr. 2010; 92:1461–1467. [PubMed: 20943796]

33. Schroder H. Protective mechanisms of the Mediterranean diet in obesity and type 2 diabetes. J Nutr Biochem. 2007; 18:149–160. [PubMed: 16963247]

34. Kastorini CM, Milionis HJ, Esposito K, Giugliano D, Goudevenos JA, Panagiotakos DB. The effect of Mediterranean diet on metabolic syndrome and its components: a meta-analysis of 50 studies and 534,906 individuals. J Am Coll Cardiol. 2011; 57:1299–1313. [PubMed: 21392646]

35. Gunderson EP, Murtaugh MA, Lewis CE, Quesenberry CP, West DS, Sidney S. Excess gains in weight and waist circumference associated with childbearing: The Coronary Artery Risk Development in Young Adults Study (CARDIA). Int J Obes Relat Metab Disord. 2004; 28:525–535. [PubMed: 14770188]

36. Gunderson EP, Sternfeld B, Wellons MF, Whitmer RA, Chiang V, Quesenberry CP Jr, et al. Childbearing may increase visceral adipose tissue independent of overall increase in body fat. Obesity (Silver Spring). 2008; 16:1078–1084. [PubMed: 18356843]

37. Smith DE, Lewis CE, Caveny JL, Perkins LL, Burke GL, Bild DE. Longitudinal changes in adiposity associated with pregnancy. The CARDIA Study. Coronary Artery Risk Development in Young Adults Study. JAMA. 1994; 271:1747–1751. [PubMed: 8196117]

38. Piers LS, Walker KZ, Stoney RM, Soares MJ, O'Dea K. Substitution of saturated with monounsaturated fat in a 4-week diet affects body weight and composition of overweight and obese men. Br J Nutr. 2003; 90:717–727. [PubMed: 13129479]

39. Fung TT, Schulze M, Manson JE, Willett WC, Hu FB. Dietary patterns, meat intake, and the risk of type 2 diabetes in women. Arch Intern Med. 2004; 164:2235–2240. [PubMed: 15534160]

40. Zhang C, Schulze MB, Solomon CG, Hu FB. A prospective study of dietary patterns, meat intake and the risk of gestational diabetes mellitus. Diabetologia. 2006; 49:2604–2613. [PubMed: 16957814]

TABLE 1

Baseline and dietary characteristics according to adherence to the alternate Mediterranean Diet (aMED)

	aMED score				
	Total cohort (n=248)	Low (score 0–3; n=87)	Moderate (score 4–5; n=106)	High (score 6–9; n=55)	p-value
Demographic characteristics					
Age (y)	27.5 (8.2)	27.3 (8.4)	27.9 (8.1)	26.9 (8.3)	0.74
Physical activity (n(%))					0.04
Low	22 (8.9)	10 (11.5)	6 (5.7)	6 (10.9)	
Moderate	90 (36.3)	21 (24.1)	46 (43.4)	23 (41.8)	
High	136 (54.8)	56 (64.4)	54 (50.9)	26 (47.3)	
Race (n(%))					0.07
White	147 (59.3)	46 (52.9)	60 (56.6)	41 (74.6)	
Black	50 (20.2)	23 (26.4)	22 (20.8)	5 (9.1)	
Other	51 (20.6)	18 (20.7)	24 (22.6)	9 (16.4)	
Married or living together (n(%))	64 (25.8)	23 (26.4)	28 (26.4)	13 (23.6)	0.92
Current smoker (n(%))	10 (4.0)	3 (3.5)	5 (4.7)	2 (3.6)	0.92
Education (n(%))					0.44
High school or less/GED	32 (12.9)	14 (16.1)	15 (14.2)	3 (5.5)	
Some college	95 (38.3)	34 (39.1)	39 (36.8)	22 (40.0)	
Associates or Bachelor degree	93 (37.5)	33 (37.9)	38 (35.9)	22 (40.0)	
Graduate school or higher	28 (11.3)	6 (6.9)	14 (13.2)	8 (14.6)	
Total energy (kcal)	1613.0 (348)	1542.3 (345.6)	1635.4 (331.5)	1681.8 (368.9)	0.04
Proteins (% of kcal)	15.7 (3.0)	15.9 (3.0)	15.9 (3.1)	15.1 (2.7)	0.23
Carbohydrates (% of kcal)	50.9 (7.0)	49.9 (6.7)	50.9 (7.1)	52.7 (6.9)	0.06
Fat (% of kcal)	33.8 (5.3)	34.5 (5.1)	33.6 (5.6)	33.2 (5.0)	0.34
SFA (% of kcal)	11.5 (2.5)	12.3 (2.3)	11.4 (2.5)	10.5 (2.4)	<0.001
MUFA (% of kcal)	12.6 (2.3)	12.6 (2.3)	12.4 (2.4)	12.6 (2.2)	0.80
PUFA (% of kcal)	7.0 (1.6)	6.6 (1.6)	7.1 (1.5)	7.6 (1.6)	0.002
aMED components					
Vegetables (excludes potatoes) (servings/d)	2.3 (1.1)	1.8 (0.7)	2.3 (1.0)	3.0 (1.3)	<0.001
Legumes (servings/d)	0.1 (0.2)	0.1 (0.1)	0.1 (0.2)	0.3 (0.4)	<0.001

	aMED score				
	Total cohort (n=248)	Low (score 0–3; n=87)	Moderate (score 4–5; n=106)	High (score 6–9; n=55)	p-value
Fruits (servings/d)	1.2 (0.9)	0.9 (0.9)	1.1 (0.9)	1.7 (0.8)	<0.001
Nuts (servings/d)	0.3 (0.6)	0.1 (0.2)	0.3 (0.5)	0.7 (0.8)	<0.001
Whole grains (servings/d)	0.8 (0.9)	0.5 (0.5)	0.9 (1.1)	1.3 (0.9)	<0.001
Red meat & products (servings/d)	1.5 (1.2)	1.8 (1.1)	1.6 (1.3)	1.0 (1.1)	0.001
Fish and seafood (servings/d)	0.4 (0.6)	0.2 (0.4)	0.6 (0.7)	0.5 (0.6)	<0.001
MUFA:SFA ratio	1.2 (0.3)	1.1 (0.2)	1.2 (0.2)	1.3 (0.3)	<0.001
Alcohol (g/d)	2.8 (5.3)	2.3 (6.4)	2.7 (4.6)	3.7 (4.4)	0.29

Figures are means (SD) unless stated otherwise. SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid. Median values for calculating the aMED component scores: vegetables excluding potatoes (2.044 servings/d), legumes (0.031 servings/d), fruits (1.021 servings/d), nuts (0.065 servings/d), whole grains (0.607 servings/d), red meat & products (1.329 servings/d), fish and seafood (0.113 servings/d), MUFA:SFA ratio (1.146).

TABLE 2

Anthropometric indices and body fat distribution according to adherence to the alternate Mediterranean Diet (aMED)

	aMED score				
	Total cohort (n=248)	Low (score 0–3; n=87)	Moderate (score 4–5; n=106)	High (score 6–9; n=55)	p-value [b]
Anthropometry					
BMI (kg/m^2)	24.1 (3.9)	25.4 (4.0)	23.2 (3.3) ***vlow	23.7 (4.2) *vlow	<0.001
Hip circumference (cm)	99.6 (8.6)	101.9 (8.9)	98.1 (7.3) **vlow	98.9 (9.7)	0.006
Waist circumference (cm)	74.8 (8.8)	77.4 (9.3)	73.1 (7.5) **vlow	73.8 (9.5) *vlow	0.002
Waist-to-hip ratio	0.8 (0.1)	0.8 (0.1)	0.7 (0.1)	0.7 (0.1)	0.22
Sum of skinfolds (mm) [a]	81.2 (22)	87.4 (23.0)	78.2 (20.8) *vlow	77.3 (20.8) *vlow	0.005
Thigh circumference (cm)	50.2 (7.0)	52.5 (7.5)	48.7 (5.7) ***vlow	49.4 (7.6) *vlow	<0.001
DXA analysis					
Percent body fat	29.5 (6)	31.2 (6.4)	28.8 (4.9) *vlow	28.2 (6.7) *vlow	0.004
Percent trunk fat	25.1 (7.4)	27.5 (7.7)	24 (6.2) **vlow	23.5 (8.1) *vlow	<0.001
Percent leg fat	35.2 (5.8)	36 (6.3)	34.9 (5.1)	34.1 (6.3)	0.15
Trunk fat mass (kg)	7.7 (3.6)	8.9 (4.0)	6.9 (2.8) ***vlow	7.2 (4.0) *vlow	<0.001
Leg fat mass (kg)	4.3 (1.3)	4.6 (1.5)	4.1 (1.1) *vlow	4.2 (1.5)	0.021
Trunk-to-leg fat ratio	1.8 (0.5)	1.9 (0.5)	1.7 (0.5) *vlow	1.7 (0.5) *vlow	0.007

Figures are means (SD).

[a] Includes the sum of subscapular, suprailiac, triceps and thigh skinfolds.

[b] Overall p-value for any significant difference between the three groups: low, moderate and high aMED.

Pairwise comparisons were performed between low and high aMED, low and moderate aMED, and between moderate and high aMED. No significant pairwise differences were observed between moderate and high aMED scores. For each significant result, a “vlow” indicates the low aMED comparison group.

* $p \leq 0.05$;

** $p \leq 0.001$;

*** $p \leq 0.0001$ by ANOVA.

TABLE 3

Multiple linear regression evaluating the association between adiposity outcomes and alternate Mediterranean Diet (aMED)

Score	Difference per 1-unit increase in aMED	95% CI	p-value
aMED			
DXA analysis			
Percent body fat			
Energy adjusted	−0.73	(−1.16,−0.29)	0.001
Fully adjusted [a]	−0.67	(−1.11,−0.24)	0.003
Percent trunk fat			
Energy adjusted	−0.96	(−1.49,−0.43)	<0.001
Fully adjusted [a]	−0.85	(−1.39,−0.32)	0.002
Percent leg fat			
Energy adjusted	−0.48	(−0.91,−0.06)	0.027
Fully adjusted [a]	−0.48	(−0.91,−0.05)	0.029
Trunk-to-leg fat ratio			
Energy adjusted	−0.06	(−0.10,−0.02)	0.002
Fully adjusted [a]	−0.06	(−0.09, −0.02)	0.005
Anthropometry			
Sum of skinfolds			
Energy adjusted	−2.99	(−4.58,−1.39)	<0.001
Fully adjusted [a]	−2.63	(−4.25, −1.00)	0.002
Waist circumference			
Energy adjusted	−1.09	(−1.73,−0.46)	<0.001
Fully adjusted [a]	−0.98	(−1.61,−0.36)	0.0023
Hip circumference			
Energy adjusted	−0.87	(−1.49,−0.25)	0.006
Fully adjusted [a]	−0.88	(−1.50,−0.25)	0.006
Waist-to-hip ratio			
Energy adjusted	−0.004	(−0.008,−0.0001)	0.043
Fully adjusted [a]	−0.003	(−0.007,0.001)	0.14
BMI			
Energy adjusted	−0.44	(−0.73,−0.16)	0.002
Fully adjusted [a]	−0.38	(−0.67,−0.10)	0.009

[a]Adjusted for energy intake (kcal, continuous), age (continuous), race (white, black, other), physical activity (high, moderate, low) and education (high school or less/GED, some college, associates or bachelor degree, graduate degree or higher).

TABLE 4

Dietary characteristics by trunk-to-leg fat ratio tertiles

	Trunk-to-leg fat ratio tertiles [a]			
	Low (n=83)	**Moderate (n=83)**	**High (n=82)**	**p-value [b]**
Total energy (kcal)	1632.8 (321.5)	1582.2 (345.1)	1624.1 (377.5)	0.61
Proteins (%)	15.4 (3.0)	15.6 (2.7)	16.1 (3.2)	0.28
Carbohydrates (%)	51.7 (6.3)	51.6 (6.8)	49.5 (7.7)	0.08
Fat (%)	33.7 (5.0)	32.9 (5.0)	34.9 (5.7)	0.05
SFA (%)	11.4 (2.5)	11.0 (2.3)	12.1 (2.6)	0.02
MUFA (%)	12.5 (2.1)	12.2 (2.3)	13.0 (2.5)	0.12
PUFA (%)	7.1 (1.7)	6.9 (1.4)	7.0 (1.6)	0.76
Total dietary fiber	14.1 (6.0)	13.2 (5.1)	13.7 (5.7)	0.61
aMED components				
Vegetables (excludes potatoes) (servings/d)	2.3 (1.2)	2.2 (0.9)	2.3 (1.2)	0.78
Legumes (servings/d)	0.2 (0.2)	0.1 (0.2)	0.1 (0.2)	0.57
Fruits (servings/d)	1.3 (0.8)	1.1 (1.0)	1.1 (0.9)	0.45
Nuts (servings/d)	0.4 (0.7)	0.2 (0.4)	0.3 (0.6)	0.05
Whole grains (servings/d)	0.7 (0.7)	0.8 (0.8)	1.0 (1.2)	0.32
Red meat & products (servings/d)	1.3 (1.1)	1.5 (1.2)	1.8 (1.2)	0.03
Fish and seafood (servings/d)	0.5 (0.6)	0.4 (0.6)	0.4 (0.6)	0.54
MUFA:SFA ratio	1.2 (0.2)	1.2 (0.2)	1.2 (0.3)	0.84
Alcohol (g/d)	2.2 (5.0)	3.2 (5.7)	2.8 (5.1)	0.42

Figures are means (SD). SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid.

[a] Mean (range) of trunk-to-leg fat ratio tertiles: Low: 1.2 (0.78–1.45), Moderate: 1.7 (1.46–1.88), High: 2.4 (1.89–3.86).

[b] Overall p-value for any significant difference between the three groups: low, moderate and high trunk-to-leg fat ratio tertiles.

TABLE 5

Results from multiple linear regression analysis that evaluated the association between trunk-to-leg fat ratio (dependent), dietary factors (independent), and other explanatory variables

	Trunk-to-leg fat ratio β-coefficient	p-value [a]
Proteins (%)	0.021 (−0.002, 0.045)	0.07
Carbohydrates (%)	−0.009 (−0.018, 0.001)	0.08
Fat (%)	0.007 (−0.006, 0.020)	0.27
SFA (%)	0.020 (−0.009, 0.048)	0.18
MUFA (%)	0.011 (−0.017, 0.040)	0.43
PUFA (%)	0.004 (−0.038, 0.046)	0.85
aMED components		
Vegetables (excludes potatoes) (servings/d)	−0.025 (−0.091, 0.040)	0.45
Legumes (servings/d)	−0.280 (−0.550, −0.010)	0.04
Fruits (servings/d)	0.0004 (−0.0739, 0.0746)	0.99
Nuts (servings/d)	−0.074 (−0.187, 0.039)	0.20
Whole grains (servings/d)	−0.0001 (−0.0723, 0.0721)	1.0
Red meat & products (servings/d)	0.060 (0.002, 0.117)	0.04
Fish and seafood (servings/d)	−0.028 (−0.139, 0.082)	0.61
MUFA:SFA ratio	−0.056 (−0.315, 0.203)	0.67
Alcohol (g/d)	0.002 (−0.011, 0.016)	0.71

[a] Adjusted for energy intake (kcal, continuous), age (continuous), race (white, black, other), physical activity (high, moderate, low) and education (high school or less/GED, some college, associates or bachelor degree, graduate degree or higher).